



SIS Acquisition

Reconsidering the Role of Systems Engineering in DoD Software Problems

Grady Campbell (ghc@sei.cmu.edu)

Sponsored by the U.S. Department of Defense
© 2004 by Carnegie Mellon University

Report Documentation Page				Form Approved OMB No. 0704-0188	
Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.					
1. REPORT DATE JAN 2004		2. REPORT TYPE		3. DATES COVERED 00-00-2004 to 00-00-2004	
4. TITLE AND SUBTITLE SIS Acquisition: Reconsidering the Role of Systems Engineering in DoD Software Problems				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Carnegie Mellon University,Software Engineering Institute,Pittsburgh,PA,15213				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution unlimited					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT Same as Report (SAR)	18. NUMBER OF PAGES 13	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			



Basic Questions

Are any software problems in
DoD acquisitions traceable to
systems engineering practices?

Would reformulating systems engineering
and its relationship to software engineering
reduce problems with software?



Background/Motivation

The DoD focus on acquiring software-intensive systems

Lack of software guidance in systems engineering sources

Experiences in working with software organizations that information from systems engineering is often inadequate

Experiences with software product lines showing that most software product diversity traces to system-level information and tradeoffs



The Immediate Context

Systems engineering is the guiding technical approach for DoD acquisition programs

Systems engineering analyzes operational needs to define and create an enhanced operational capability

Systems engineering specifies required system behavior and decomposes the system into subsystems

Systems engineering is a primary conduit and filter for information to subsystem developers

Software engineering is seen as a specialized discipline focused on constructing software subsystems



Significance

Any reasonably complex system has software as a critical element

Software is always part of a broader system

Systems and software decision making are interdependent and need shared visibility:

- Systems decisions constrain software alternatives
- Software decisions can significantly affect the emergent properties of a system

Systems engineering and software engineering need to overcome a conceptual incompatibility (physical versus information views of a system)



Perceived problems for software

Lack of clear and complete information on needs

Failing to consider software properties and implications in system-level designs and trade studies

Software decisions (“after” systems engineering) that affect system properties

Systems engineering decisions that unnecessarily limit or complicate software alternatives

Poor fit of a top-down systems-software process to actual objectives (diverse or changing requirements)



Relevance to DoD

DoD buys systems but software is both a critical enabler and a prominent source of risk (both product and process)

Systems engineering practices contribute to software risks if they:

- Prematurely over-constrain software engineering choices
- Inadequately communicate information, including unknowns and uncertainties, needed for effective software engineering
- Fail to adequately represent and analyze the implications of software design choices in system-level trade studies

Attempting to fix software engineering problems without rethinking the role of systems engineering may limit any potential for improvement



References

Systems Engineering Fundamentals, DoD Systems Management College, Jan. 2001.

Systems Engineering Capability Maturity Model[®] (1995) & *Capability Maturity Model Integration*[®] (2002), Software Engineering Institute.

R. Stevens, et. al., *Systems Engineering – coping with complexity*, 1998.

B. Thomé, *Systems Engineering - Principles and Practice of Computer-based Systems Engineering*, Wiley, 1993.

W. Wood, et.al., *DoD Architecture Framework and Software Architecture Workshop Report*, CMU/SEI-2003-TN-006, March 2003.

G. Campbell, *A Software Product Line Vision for Defense Acquisition*, CMU/SEI-2002-TN-002, June 2002.



Questions for Further Investigation

- Are perceived problems of systems-software interdependencies and conflicts real and pervasive?
- Are there reasonable refinements or alternative reformulations of systems-software engineering that might reduce software problems?
- Could systemic reform of the systems-software engineering process and practices and applicable DoD policy produce improved results for acquisition?



Some Goals for System-Software Interdependence

- System-software requirements and designs are iteratively refined
- Systems engineering applies software expertise to identify and evaluate alternative system decompositions
- Estimations of system attributes account for how software decisions can affect emergent properties
- Human interface requirements reflect current software capabilities
- Information on uncertain and changing needs is communicated to guide designing for change



Prospective Reformulations of Systems-Software Engineering

(or transitional stages)

- Improve systems engineering performance by refining current methods & maturing their use in practice (e.g., CMMI®)
- Apply software practices in systems engineering to identify and analyze alternatives and system-level implications
- Closely integrate and iteratively apply systems and systems-level software engineering for analysis and design
- In systems engineering, build a system first as an abstract computation over an information model of the enterprise – substitute hardware for software as needed to optimize and deploy



Related, Advanced Topics

Process improvement

Hardware-software co-design

Product lines and mass customization

Modeling and emulation of hardware in software



A Call for Discussion and Action

- Share perspectives and perceptions of software-intensive systems engineering
- Report on alternative system-software relationships in theory or practice
- Pursue answers to ‘questions for further investigation’
- Initiate efforts to collaboratively reformulate systems engineering for SIS or revise DoD policy accordingly